

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
17 April 2003 (17.04.2003)

PCT

(10) International Publication Number
WO 03/031812 A1

(51) International Patent Classification?: **F03D 1/00**,
11/02, 11/00

(21) International Application Number: **PCT/IB02/04375**

(22) International Filing Date: **4 October 2002 (04.10.2002)**

(25) Filing Language: **English**

(26) Publication Language: **English**

(30) Priority Data:
0123973.0 **5 October 2001 (05.10.2001)** **GB**

(71) Applicant (for all designated States except US): **HANSEN TRANSMISSIONS INTERNATIONAL NV [BE/BE]**;
Leonardo Da Vincilaan 1, B-2650 Edegem (BE).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **FLAMANG, Peter [BE/BE]**; Hansen Transmissions International NV,
Leonardo Da Vincilaan 1, B-2650 Edegem (BE).

(74) Agent: **BADGER, John, Raymond**; Invensys Intellectual Property, P.O. Box 8433, Redditch B98 0DW (GB).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

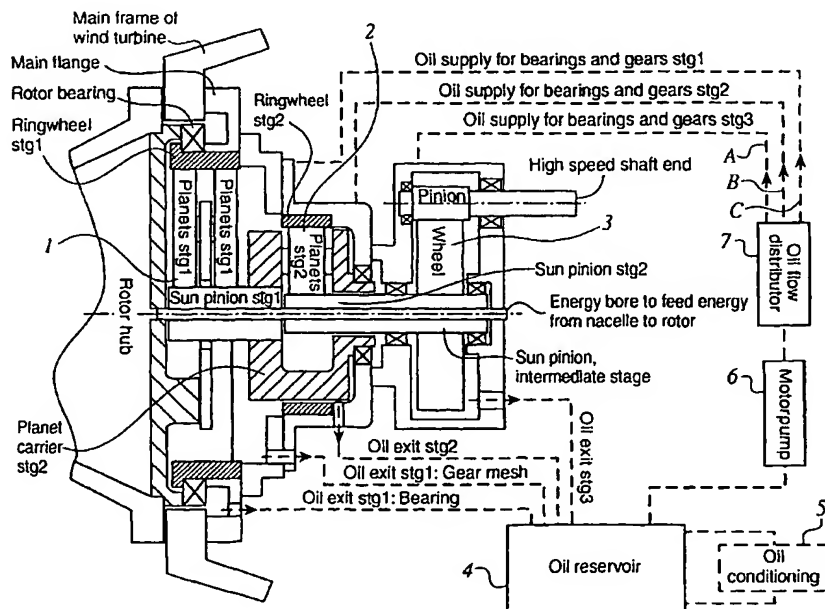
(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: **DRY SUMP LUBRICATION SYSTEM WITH REMOVABLE OIL RESERVOIR FOR WIND TURBINE GEARBOX**



(57) Abstract: A gear unit for use in wind turbine applications has a dry sump and is lubricated from an external reservoir whereby routine oil change may be undertaken by removing an external reservoir containing used oil and replacing it by a reservoir containing fresh oil.

DRY SUMP LUBRICATION SYSTEM WITH REMOVABLE OIL RESERVOIR FOR WIND TURBINE
GEARBOX

The present invention relates to a gear unit and particularly but not exclusively to a gear unit for a wind turbine.

Because of their position high up in the nacelle, a key success factor of gear units for wind turbines is to provide low weight and compactness. This has lead in the last decade to the quasi general introduction of planetary low speed gear stages for gear units in the power range beyond 500 kW and is now, in the development of multi-MegaWatt turbines, leading to more and more gear units with planetary low speed and intermediate gear stages.

This evolution is leading to new challenges for the designers of such turbines.

A basic characteristic of a planetary gear stage is that it can contain only a very limited quantity of oil. A minimum quantity of oil however is required in the lubrication system of the gear unit to ensure that the oil does not degrade too fast and oil change intervals are maximized.

At the same time, requiring large oil quantities complicates oil changes on top of the nacelle due to cost and time involved in the transport of oil barrels, draining and filling of the gear unit

By the nature of its construction, there are several disadvantages to using the gear unit housing as the oil reservoir : the oil is continuously churned around which leads to efficiency losses and high cold-start torques, as well as possibly faster oxidation because of a more intense contact of the oil with air, foam building that can disturb lubrication systems and for instance oil level alarms, etceteras.

Gear units typically contain several oil pockets that are hard to flush when the oil is changed. Also, contamination of the oil bath due to a failing component may easily lead to consequential damage of other components as the particles from the failing component are coming in the common oil sump of the gear unit.

The present invention provides a novel solution for the specific problems mentioned above.

The basic idea of the present invention is to completely eliminate the oil sump in the gear unit. A separate oil reservoir is installed, from which well conditioned (cooled and filtered) oil is fed to the gear unit. Although central lubrication systems exist that provide oil for instance to different gear units in the same plant or even to a single gear unit, these gear units mostly still also need to enjoy the benefit of their own oil baths. Also the use of external oil reservoirs, which in general would be regarded as contrary to the objective of compactness, is not known in wind turbine gear unit design.

Eliminating the oil bath in the gear unit as a whole however can solve a number of the issues mentioned above. The uncoupling of the gear unit lubrication circuit from the oil conditioning circuit by means of an external oil reservoir moreover simplifies the monitoring of the oil conditioning equipment itself, such as oil heaters, cooling systems and filter systems.

As a further part of this invention, the gear unit is constructed in such a way that the main gear stages are forming separate modules, each of which receives fresh conditioned oil from the lubrication system and returns the used oil separately to the external oil reservoir. This has the advantage that

contaminating particles in one of the modules, for instance created by a failing component or by external factors such as dirt or water accumulation, are not allowed to contaminate the other modules, but are intercepted by the separate oil conditioning system of the reservoir.

Each of the return lines can be provided with a debris trap device for instance by means of a transparent small reservoir provided with a magnet and allowing visual inspection of the presence of particles or debris.

Furthermore, the present invention also proposes to use an oil reservoir that can be easily removed from the nacelle and replaced by another fresh oil reservoir that contains well conditioned oil. This exchange may include the most important parts of the oil conditioning unit such as heaters, coolers and filtration systems. The lubrication system thus receives a complete "reset" at any oil change, removing all possibly accumulated dirt or debris and also avoiding time consuming flushing of oil tanks on-board of the nacelle. Against a background of a growing off-shore market for wind turbines that are even more difficult to service, this may be a large advantage.

A particularly interesting embodiment of the present invention is shown in Figure 1 which shows a schematic diagram of cross-section of a gear unit and plural lubrication circuits A, B, C and each serving a different module of the gear unit.

The shown gear unit consists of three modules comprising two planetary gear stages 1 and 2 and a helical high speed gear stage 3. The wind turbine rotor bearing arrangement is integrated in the gear unit.

Fresh oil is fed from the external reservoir 4 by means a pump 6 and via a flow distributor 7 to the three different modules of the gear unit, and returned from these modules back to the reservoir. The reservoir is provided with a separate oil conditioning circuit 5.

For this particular construction, the invention with a dry sump offers the additional advantage that the sealing arrangement which has to be provided at a very large diameter, does not have to seal of against any hydrostatic pressure that would be present in case of an oil sump, and can therefore be based on non-contacting sealing principles.

CLAIMS

1. Gear unit for use in wind turbine applications characterised by the fact that the gear unit has a dry sump and is lubricated from an external reservoir
2. Gear unit according to claim 1 characterised by the fact that the gear unit consist of several modules each of which receives fresh oil from the lubrication system and returns the used oil to the external reservoir.
3. Gear unit according to claim 1 and 2 characterised by the fact that each return line is equipped with a debris trap device allowing evaluation of each of the modules.
4. Gear unit according to claim 1 characterised by the fact that the regular oil change is carried out by removing the complete external oil reservoir and replacing it with a fresh oil reservoir
5. Gear unit according to claim 3 characterised by the fact that not only the oil reservoir is exchanged at the time of oil change, but also a number of dedicated parts of the oil conditioning system attached to the reservoir.
6. Gear unit according to claim 1 and 2 characterised by the fact that the gear unit comprises an integrated wind turbine rotor bearing arrangement that is also lubricated with fresh oil from the same reservoir.
7. Gear unit according to claim 5 characterised by the fact that the gear unit is sealed at a large diameter by a sealing arrangement whose function is based on non contacting sealing principles.

1/1

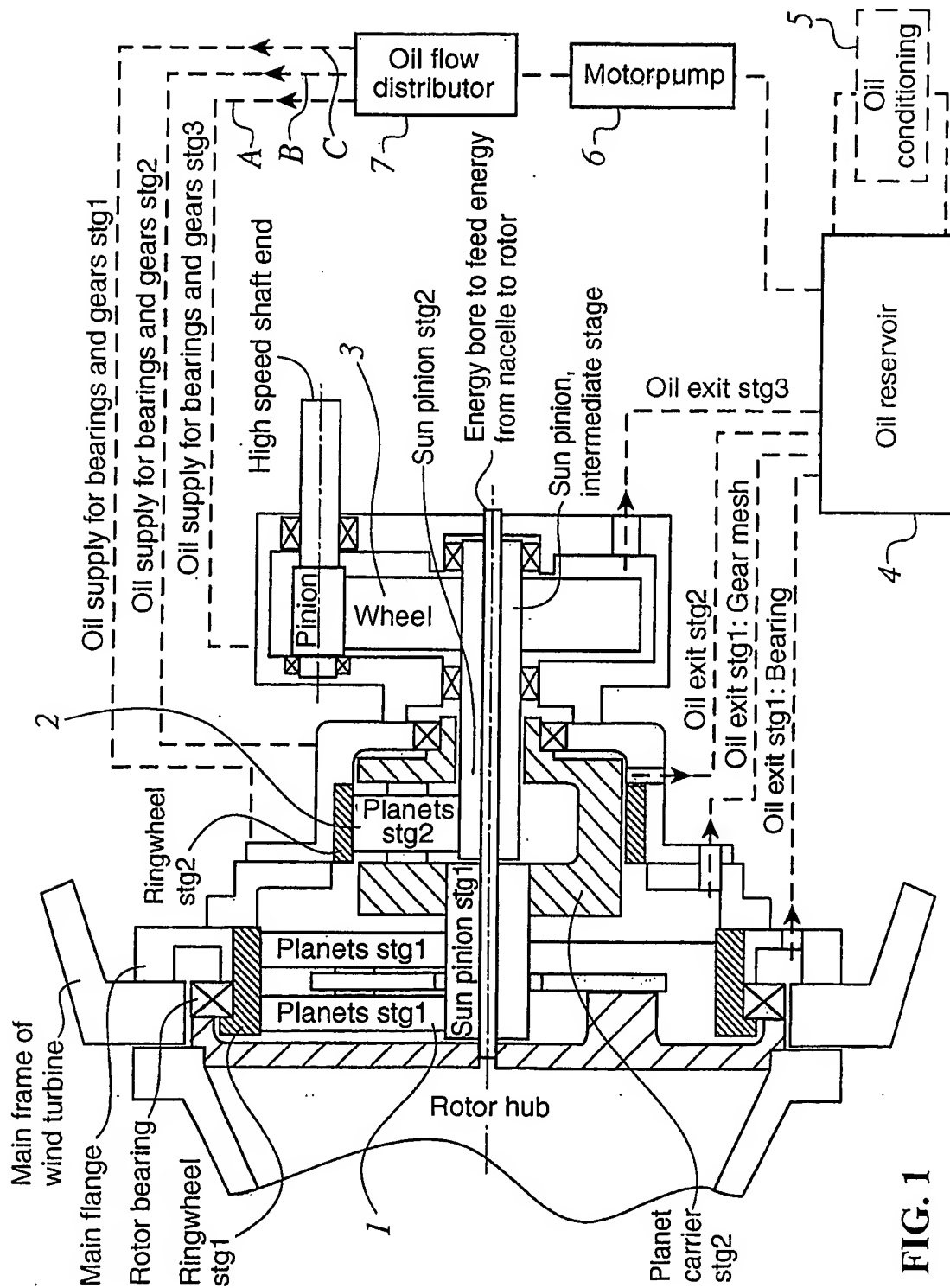


FIG. 1

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/IB 02/04375

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F03D1/00 F03D11/02 F03D11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F03D F16F F16H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 201 200 A (BERGISCHE STAHLINDUSTRIE) 24 August 1988 (1988-08-24) abstract column 3, line 23 -column 4, line 10 column 2, line 62 -column 3, line 12	1,4,5
Y	----	2,3,6,7
Y	DE 199 52 780 A (DAIMLER CHRYSLER AG) 23 May 2001 (2001-05-23) abstract column 1, line 59 -column 2, line 9 column 2, line 32 - line 42 column 2, line 62 -column 3, line 12	1,4,5
Y	DE 197 56 253 A (AISIN AW CO) 25 June 1998 (1998-06-25) abstract column 5, line 49 - line 62; figure 6 ----- -/-	2

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the International filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the International filing date but later than the priority date claimed

- *T* later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *Z* document member of the same patent family

Date of the actual completion of the International search

19 December 2002

Date of mailing of the International search report

02/01/2003

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Criado Jimenez, F

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/04375

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 615 413 A (STEVENSON BASIL C J) 7 October 1986 (1986-10-07) abstract ---	3
Y	WO 96 11338 A (HEHENBERGER GERALD) 18 April 1996 (1996-04-18) page 1, line 36 -page 2, line 40 page 3, line 21 - line 29; figure 3 ----	6
Y	US 4 072 067 A (BENTHAKE HEINRICH) 7 February 1978 (1978-02-07) column 3, line 4 - line 8; figure ---	7
A	DE 199 63 597 A (MANNESMANN AG) 26 July 2001 (2001-07-26) abstract; figures -----	1

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 02/04375

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
GB 2201200	A	24-08-1988	DE	3702008 A1	04-08-1988
			SE	8800052 A	24-07-1988
DE 19952780	A	23-05-2001	DE	19952780 A1	23-05-2001
DE 19756253	A	25-06-1998	JP	10184857 A	14-07-1998
			DE	19756253 A1	25-06-1998
US 4615413	A	07-10-1986	DE	3472153 D1	21-07-1988
			EP	0126554 A2	28-11-1984
WO 9611338	A	18-04-1996	AT	403310 B	26-01-1998
			WO	9611338 A1	18-04-1996
			AT	209753 T	15-12-2001
			AU	3597095 A	02-05-1996
			DE	59509888 D1	10-01-2002
			EP	0792415 A1	03-09-1997
			ES	2166832 T3	01-05-2002
			AT	216694 A	15-05-1997
US 4072067	A	07-02-1978	DE	2518113 A1	28-10-1976
			BE	841096 A1	16-08-1976
			FR	2308836 A1	19-11-1976
			GB	1543756 A	04-04-1979
			JP	51130765 A	13-11-1976
DE 19963597	A	26-07-2001	DE	19963597 A1	26-07-2001
			AU	2349301 A	16-07-2001
			WO	0150038 A1	12-07-2001
			EP	1240443 A1	18-09-2002

This Page is inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ BLACK BORDERS
- ☒ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLORED OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images
problems checked, please do not report the
problems to the IFW Image Problem Mailbox**